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ABSTRACT

The four papers in this collection discuss language perception and comprehension and report on experiments in those areas. The first paper, "The Influence of Non-Linguistic Knowledge on Perceiving and Verifying Sentences," discusses the reliance of language perception and comprehension on the interaction of linguistic and world knowledge. "The Influence of Context-Dependent Comprehensibility on Sentence Perception" discusses two experiments suggesting that shadowing linguistically well-formed sentences was more accurate when the sentences were prefaced by context cues that improved their comprehensibility and that the context effect was due to the improved comprehensibility of sentences as a whole in context. In "Elastic Semantic Distance," the notion of fixed semantic distances among items in semantic memory is questioned in light of two sentence verification studies suggesting that verification of true statements was reliably faster when target sentences were preceded by relevant rather than irrelevant context sentences. The final paper, "Direct Comprehension of Individually Presented Words," reports on a study that yielded results related to the implication of visual imagery mechanisms in auditory word identification and the notion of "direct comprehension." (GW)

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FINAL REPORT

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THE INFLUENCE OF NON-LINGUISTIC KNOWLEDGE ON PERCEIVING AND VERIFYING SENTENCES

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INTRODUCTION

BACKGROUND AND RATIONALE

According to the "constructive approach" to language comprehension (e.g., Barclay, 1973; Bransford, Barclay, and Franks, 1972), listeners construct semantic representations by actively assimilating linguistically expressed information to their relevant knowledge of the world (see Glanzman and Pisoni, undated, for additional comparisons with other theoretical approaches). This pre-theoretical formulation recently has generated sufficient empirical support to encourage its further development. The present research was designed to facilitate elaboration of the constructive approach.

The sections which follow begin with a brief description of two types of empirical support for the constructive approach, thereby setting the stage for raising several questions concerning the influence on contexts of non-linguistic knowledge on perceiving, verifying, and remembering sentences. Those questions were addressed by the present series of experiments, with theoretical implications of the research discussed in the remarks which introduce individual experiments or groups of experiments.

Empirical Support for the Constructive Approach

Two major lines of evidence supporting the constructive approach are discussed below in order to establish the conceptual framework which guides the present research. Additional empirical support may be found in the work of Barclay and Reid (in press) and Bransford and Franks (1972) on semantic integration. The approach also has much in common with constructive theories of cognitive processing in general, as found, for example, in the views of Neisser (1967) and Piaget (e.g., Piaget and Inhelder, 1969).

1. Listeners remember having heard information which they inferred from presented sentences. Assume that semantic representations of perceived sentences (or sentence sets) are constructed out of the relationships between linguistically expressed information and relevant world-knowledge, and that the product of comprehension underlies recall and recognition of presented materials. If so, it is reasonable to expect that memory representations of sentences may contain more (or different) information than was actually expressed. Therefore, listeners should erroneously remember having heard (or seen) information which they in fact inferred or deducted from presented sentences. Several studies have confirmed this expectation. Bransford, Barclay, and Franks (1972) found that subjects could not remember which final pronoun they had heard in sentences like (1a), although they were relatively good at remembering final pronouns in control sentences like (1b):

(1a) Three turtles rested on a floating log and a fish swam beneath it/them.

(1b) Three turtles rested near a floating log and a fish swam beneath it/them.

Note that either version of (1a) can be inferred from the other, while such is not true of (1b). In studies by Barclay (1973), Barclay and Reid (in press; in preparation), Barclay and Lalentin (in preparation), and Steinheiser (1972), subjects were presented with sets of short comparative sentences describing linear arrays of objects. In both recall and recognition, subjects who had used the sentences to determine the linear ordering (rather than memorizing the sentences) confused acquisition sentences with their logical equivalents and with transitive inferences. Other types of inferential memory errors were also observed (e.g., Barclay, 1973). Similar results were obtained by Potts (1973) with a passage of connected discourse, and in an earlier study (Potts,

1972) he found that verification latencies for inferred statements were actually shorter than those for presented statements.

While these phenomena are predictable from the constructive point of view, they are problematical for theories which assume (at least tacitly) that a full linguistic analysis of sentences would provide all of the information necessary to characterize the product of comprehension (e.g., deep structure theories of the sort described by Rohrman, 1968, and semantic feature theories of the sort proposed by Clark, 1969). However, it might be suggested that one need only append a few basic logical operations to the processes which perform the psychological equivalent of linguistic analysis in order to account for these findings. It would then be necessary to postulate a more complex relationship between sentential information and general cognitive knowledge in comprehension. There appear to be movements in this theoretical direction in recent computer programs for processing natural language (see Minsky, 1968; but also see Winograd, 1972, for a different approach). However, other studies reveal that the inferences listeners spontaneously incorporate into their constructed semantic representations depend strongly on knowledge about the world, rather than on simple formal-logic mainpulations of input "premises." For instance, Johnson, Bransford, and Solomon (in press) found that subjects falsely recognized statements which mentioned instruments inferrably used to perform acts described by acquisition sentences. Thus, subjects were much more likely to think they had heard (2a) when they had actually heard pounding, rather than looking for, in (2b):

(2a) John was using the hammer to fix the bird house when his father came out to watch him and to help him do the work.

(2b) John was trying to fix the bird house. He was pounding/looking for the nail when his father came out to watch him and to help him do the work.

Johnson et al. also reported a second study in which subjects falsely recognized statements of inferred consequences of events described by acquisition sentences. For example, subjects more often falsely recognized (3a) when they had heard threw. . .into rather than pulled. . .from in (3b):

(3a) The spy burned the secret document just in time since thirty seconds longer would have been too late.

(3b) It was late at night when the phone rang and a voice gave a frantic cry. The spy threw/pulled the secret document into/from the fireplace just in time, since thirty seconds longer would have been too late.

As final illustration of this point, consider the following sentences:

(4a) The floor was dirty because Sally used the mop.

(4b) The floor was dirty so Sally used the mop.

Sentences like (4a), in contrast to (4b), require that listeners construct some situation that justifies the causal relationship between the floor was dirty and Sally used the mop, such as inferring that the mop was dirty. McCarrell, Bransford, and Johnson (in preparation) found that sentences like The mop was dirty before Sally washed the floor were more likely to be falsely recognized by subjects who had heard (4a) than by those who had heard (4b). Again, the role of inferences involving knowledge about the world, rather than simple logical manipulations of presented information, is evident.

It seems clear that non-linguistic knowledge of the world strongly determines the produce of comprehension, and that therefore theories which restrict information in semantic representations to that disclosed by a

strictly linguistic analysis cannot adequately explain comprehension. This problem is attracting increasing attention among linguists (e.g., Fillmore, 1971b; Lakoff, 1971, see also Bolinger, 1965, for some closely related considerations). There seems to be a growing awareness that a complete linguistic analysis of a sentence can at best explicate syntactic and semantic constraints the listener uses in assimilating sentential information to his knowledge system in comprehension.

2. Comprehending and remembering sentences depend strongly on contexts of knowledge to which sentential information is assimilated. Among the clearest demonstrations of the role of knowledge contexts in comprehension are those showing that a given sentence or passage is difficult to comprehend and remember in isolation, while that same material is relatively easy to comprehend and remember when its assimilation to an appropriate context is facilitated. Ellipses, the theoretical importance of which has been underrated, constituet a special case of this phenomenon, but given the lack of empirical work on them and given the nature of the proposed research, only situations involving syntactically well-formed sentences will be discussed here.

Bransford and Johnson (1972) presented a passage which subjects rated as quite difficult to understand in isolation, but as easy to understand when accompanied by a drawing which depicted certain important spatial relations among objects. The drawing thus represented a context of knowledge which rendered an otherwise incomprehensible passage easy to understand. Consequently, subjects who saw the drawing before hearing the passage (Context Before condition) recalled the passage much more accurately than did subjects who did not see the drawing (No Context condition).

Subjects who saw the drawing after hearing the passage (Context After condition) and those who saw a drawing of the same objects in a different configuration (Partial Context condition) also recalled the passage poorly. The Context Before versus Context After comparison is particularly interesting, in that it emphasizes the role of appropriate knowledge contexts during the initial processing of sentences. Subjects were unable to retain the incomprehensible passage long enough to assimilate it to a context given a short while later. Using the same materials, Nyberg and Cleary (reported in Bransford and Johnson, 1973) found that cueing recall with key words yielded the same pattern of results (see also the study by Cole, reported in Bransford and Johnson, 1973).

One possible problem associated with the studies just described is that the situation to which the passage and drawing referred was highly unusual and presumably novel to subjects. Thus, it might be argued that the findings generalize only to a narrow range of contrived and unrepresentative circumstances. However, similar results have been found in studies in which the relevant contexts of knowledge involved familiar topics. For example, Dooling and Lachman (1973) found the recall of metaphorical passages entitled "Christopher Columbus Discovers America" and "Washing the Dishes" was better when the titles preceded their respective passages than when titles followed or were omitted. Similar findings were reported by Bransford and Johnson (1972) in a study using a passage from which the following exerpt is taken:

(5) The procedure is actually quite simple. First you arrange things into different groups. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is

the next step, otherwise you are pretty well set. It is important not to overdo things.

Without prior knowledge that the topic was "Washing Clothes," subjects found the passage difficult to comprehend (as indicated by subjective ratings) and recall, even if the topic was announced at the end of the passage. When other subjects were given the topic before hearing the passage, comprehension and recall were much better.

The previously described study in which subjects who had heard sentences like The floor was dirty because Sally used the mop falsely recognized inferentially related statements like The mop was dirty before Sally washed the floor (McCarell, Bransford, and Johnson, in preparation) is also relevant here. Note that the inferred information (the mop was dirty) can be considered a context of knowledge necessary for making sense of an otherwise rather anamolous sentence.

As another illustration, consider the sentence The notes were sour because the seams split. When presented in isolation, such sentences are difficult to comprehend, and, consequently, to remember. However, when preceded by a cue which activates the appropriate context of knowledge, e.g., Bagpipes, comprehensibility and recall improve markedly (Doll, Lapinsky, Bransford, and Johnson, in preparation; McCarrell, Bransford, and Johnson, in preparation; see Bransford and Johnson, 1973).

It seems clear that world-knowledge affects comprehension not only by providing inferred information which is integrated with that expressed, but also by providing a context to which a sentence must be actively related if it is to be properly comprehended. The studies discussed above suggest that if this assimilatory process is impeded or blocked such that the listener fails to relate sentential information to an appropriate context,

comprehension is impaired or prevented. Given the intimate relation between comprehension and memory, the latter is also impaired under such conditions.

To summarize, within the constructive approach, comprehension involves (a) determination of the information expressed by a sentence, (b) activation of an appropriate context of knowledge to which that information is assimilated, and (c) the assimilatory process itself, which for the present will be said to include inferential operations which draw upon knowledge of the world.[1] As will become clearer below, it is not suggested that components (a) to (c) are serially ordered in real-time processing.

A number of theoretically interesting questions may be raised within the constructive approach sketched above. No doubt the most important, and unfortunately the most difficult to answer, is that which asks for a precise explanation of the phrase "relating sentential information to a context of knowledge." That act, being essentially the creation and modification of knowledge itself, cannot as yet be clearly explicated. Other questions are however more approachable, and their answers may provide constraints helpful in attacking the more difficult issues.

The first question to which the present research was directly addressed asks whether and in what way contexts of knowledge critical for comprehension affect the initial perception of sentences. Notice that in terms of what has been said so far, it would be reasonable to hypothesize that knowledge contexts exert their influence only after the information expressed

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[1]The phrase "information expressed by a sentence" may be taken to include the information given in linguistic presuppositions and entailments (Fillmore, 1971a, Lakoff, 1971) without affecting the thrust of the arguement.

by a sentence has been extracted. However, if it can be demonstrated that non-linguistic knowledge affects not only the comprehensibility but also the immediate perception of syntactically well-formed sentences, than that hypothesis would be untenable. "Immediate perception" is defined operationally here as the identification of words in correct sentential sequence.

In short, the present research in part tested the working hypothesis that perceptual representations of sentences are constructed by means of processes in which non-linguistic knowledge plays a significant role. A constructive view of perception per se is itself hardly novel (e.g., Neisser, 1967), and the notion that language perception is in some sense a "constructive" process is also familiar. However, previous studies of language perception have focused almost exclusively on the influence of linguistic knowledge. Thus, perception has been shown to be affected by subject's knowledge about statistical chara teristics (Broadbent, 1967; Goldiamond and Hawkins, 1958; Miller, Heise, and Lichten, 1950; Savin, 1963; Solomon and Postman, 1952), phonological structure (Abramson and Lisker, 1967; Day, 1969), syllabic and morphological structure (Foss and Swinney, 1973; Miller et al., 1950; Savin and Bever, 1970), syntactic surface structure (Fodor and Bever, 1965; Garrett, Bever, and Fodor, 1966; Holmes, 1973; Holmes & Forster, 1970; Martin, 1968a,b; Martin and Strange, 1968; Mehler and Carey, 1967; Miller and Isard, 1963), syntactic deep structure (Bever, Lackner, and Kirk, 1969; Holmes and Forster, 1972; Mehler and Carey, 1967; Stanners, Headley, and Clark, 1972), and semantic structure (Martin, 1968a,b; Miller and Isard, 1963).

However, there are also indications that non-linguistic knowledge influences constructive aspects of speech perception. Although usually discussed within a very different theoretical framework, the phenomenon

of verbal summation (Skinner, 1936; Trussell, 1939) may be regarded as a case in which non-linguistic knowledge leads the listener to hear particular words, phrases, or sentences in a low-strength or noisy acoustical signal containing none of these. More recently, Rosenberg and Jarvella (1970a,b) found that when presented under white noise, "semantically well-integrated" sentences like The dog chased the cat were shadowed more accurately than "semantically poorly-integrated" sentences like The dog scared the goat. The difference between these two sentence types can reasonably be attributed to listeners' familiarity with the events described.

To summarize, there are numerous indications that perceptual representations of sentences are constructions rather than simple copies of acoustic stimuli, and that linguistic knowledge plays an important role in this process. The present research was in part designed to investigate the less-thoroughly explored role of non-linguistic knowledge in this regard, an issue which must be resolved if an accurate model of the conversion from acoustic signal to semantic representation is to be developed.

RESEARCH ON SENTENCE PERCEPTION

Three experiments were completed in this area. The first two are described in the manuscript which follows, to which is appended a summary description of the other study.

THE INFLUENCE OF CONTEXT-DEPENDENT COMPREHENSIBILITY ON SENTENCE PERCEPTION

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Short title: Context and Sentence Perception

ABSTRACT

Shadowing linguistically well-formed sentences such as The notes were sour because the seams were split was more accurate when the sentences were prefaced by context cues which improved their comprehensibility (e.g., bagpipes). The results of a second experiment together with free association data suggested that the context effect was not due to previously established relationships between context cues and each corresponding target word per se, but rather to the improved comprehensibility of the sentence as a whole in context. The findings are discussed in terms of two issues, one dealing with the relationship between word meaning and perception and the other with the appropriate incorporation of contextual "world knowledge" in models of sentence processing.

THE INFLUENCE OF CONTEXT-DEPENDENT COMPREHENSIBILITY ON SENTENCE PERCEPTION

This paper reports two experiments which dealt with the influence of a sentence's comprehensibility on its perception. Previous research on this topic has focused mainly on linguistically specified aspects of comprehensibility, the goal of such research being to demonstrate and elucidate the listener's use of linguistic knowledge in constructing perceptual representations of messages. Thus, McNeill (1970), Miller and Isard (1963), and Martin (1968a,b) showed that syntactically ill-formed strainges were more difficult to shadow than were syntactically regular ones, presumably because the irregular strings disallowed the listener's use of tacit syntactic rules to guide constructive aspects of the perceptual process. Additional evidence for the use of syntactic knowledge in sentence perception has been found in numerous other studies involving a variety of perceptual tasks and performance measures (e.g., Bever, Lackner, & Kirk, 1969; Garrett, Bever, & Fodor, 1966; Holmes & Forster, 1972; Mehler & Carey, 1967; Stanners, Headley, & Clark, 1972). More directly relevant to the present research are previous perceptual studies which manipulated comprehensibility by systematically violating rules of (linguistic) semantic structure with syntax held constant.[1] The studies by McNeill (1970), Miller and Isard (1964), and Martin (1968a,b) cited above provide the clearest examples : in those studies, semantically anomolous but syntactically regular strings were harder to shadow than fully grammatical ones.

In general, the line of research exemplified by the above studies depicted a direct covariation of sentence perceptibility and comprehensibility, and was predicated on the notion that comprehensibility was largely equivalent to linguistic well-formedness. In the present research we investigated a different aspect of comprehensibility: its dependence on the listener's ability to assimilate sententially specified information to an appropriate context of non-linguistic "world knowledge". Several studies have shown that sentences and discourse passages which are linguistically well-formed and which contain familiar vocabulary items may nonetheless be quite difficult to understand unless the listener can easily relate them to relevant cognitive contexts. Consider for example the sentences The notes were sour because the seams were split and The streak blocked the light, which seem relatively incomprehensible unless one knows that they refer to bagpipes and a dirty window, respectively. McCarrell, Bransford, and Johnson (reported in Bransford & McCarrell, 1974) examined cued recall of such sentences under two conditions. In one, each sentence was paired during acquisition with its subject noun, while in the other each sentence was paired with an appropriate context cue designed to enhance comprehension (e.g., bagpipes). Recall cued by subject nouns was far better in the latter condition, presumably because the sentences were easier to understand during acquisition. Essentially similar phenomena have been demonstrated with discourse passages in situations where the appropriate cognitive context was unfamiliar prior to its introduction during the experiment (Bransford & Johnson, 1973), and where the context was familiar but difficult to discern without explicit cues such

as a title for the passage (e.g., Bransford & Johnson, 1973; Dooling & Lachman, 1971).

Given that the comprehensibility of a linguistically well-formed sentence depends in part on the ease with which a listener can actively relate its information to a relevant context of world knowledge, we asked whether this aspect of comprehensibility, like linguistic aspects, influences the construction of perceptual representations of sentences. Aside from contributing information pertinent to theories of sentence perception, an affirmative answer would bear on two additional issues. The first concerns the relationship between word meaning and perception. If the perceptibility of words in a sentence varies directly with the context-dependent comprehensibility of the sentence, then one of three hypotheses seems likely: (1) activating an appropriate cognitive context for a sentence primes perceptual representations of related words, such that when some of those words occur in a subsequently presented sentence their perception is facilitated; (2) the activated cognitive context increases the probabilities of occurrence of certain words sufficiently for them to be guessed correctly on the basis of otherwise inadequate physical information; or (3) a word is more easily perceived when it's meaning forms part of an integrated, comprehensible whole as opposed to an incomprehensible aggregate of meanings-- an hypothesis which entails the notion that at least part of a word's meaning is apprehended before the word is consciously identified.

The second issue concerns the question of how best to incorporate world knowledge in models of sentence processing. For example, by themselves the results of the experiments on context and comprehensibility

cited above would be consistent with models in which relevant world knowledge becomes influential only after linguistic knowledge has been used to construct a perceptual representation and to extract a sentence's semantic content, the latter then being referred to an appropritae cognitive context in order to complete the act of comprehension. If the relationship between (linguistic) semantic content and relevant world knowledge can be shown to influence immediate perception of the sentence, such models would be clearly inaccurate.

The two experiments below were designed to demonstrate the effect of context-dependent comprehensibility on sentence perception, and to narrow the choice among the three hypotheses advanced above. In the first study, subjects attempted to shadow aloud sentences which were considered difficult to understand in isolation but easy to understand in context, such as The notes were sour because the seams were split. Our working hypothesis predicted superior shadowing when the sentences were prefaced by context-inducing cues which increased sentence comprehensibility.

EXPERIMENT 1

Method

Subjects. Twenty-four University of Colorado undergraduates from an introductory psychology course partially fulfilled course requirements by volunteering to serve as subjects. All were native speakers of English with normal hearing.

Materials and Apparatus. Test materials consisted of 24 target sentences and eight highly comprehensible fillers. Each target sentence was judged by the experimenters to be relatively incomprehensible in

isolation but quite comprehensible when prefaced by an appropriate context cue, as in the previous examples. All sentences were recorded on tape with normal intonation by a male reader. Their order was random but for the constraint that two filler sentences begin and end each of two blocks of 16 sentences (thus there were 12 target sentences per block). The inter-sentence interval was approximately 5 secs. Context cues were typed on standard 3 x 5 in. cards (one cue per card).

During presentation the stimuli were mixed with the output of a white-noise generator (modulated by a decade attenuator) and played binaurally through headphones. Two noise levels were used (a between-subjects variable). Signal and noise levels were selected on the basis of pilot data so as to produce overall shadowing accuracies of roughly 50% and 75% at comfortable listening levels. All responses were tape recorded and later transcribed for scoring.

Procedure. After shadowing 5 brief discourse passages for practice, subjects were instructed to listen carefully to each of the test sentences to follow and to repeat each word aloud as quickly as possible. (Actually, word shadowing was more the exception than the rule: most often, portions of test sentences were repeated in 2-4 word clusters.) Subjects were told that many of the sentences had been intentionally made difficult to understand, and that they should always repeat exactly what they heard even if it seemed nonsensical. Guessing was encouraged.

Each subject participated in two conditions, Context and No Context (one condition for each block of trials). They differed only in that

in the Context condition, the onset of each sentence was preceded by the experimenter's holding up the cue card appropritte for that sentence. Subjects were told only that the cues provided information that might be helpful; their relationships to the sentences were not further specified.

The design permitted counterbalancing of block order, condition order, and ssignment of sentences to conditions. Counterbalancing measures combined with the between-subjects variable of noise level (low, high) yielded eight sub-groups, to which the individually tested subjects were randomly assigned.

Results and Discussion

Responses were scored for the number of content words correctly shadowed within each block of trials (excluding fillers). Most of the content words were nouns, verbs, adjectives, and adverbs, although some prepositions were included because they were essential to sentence meaning. Two scoring systems were used: verbatim, and a more liberal scoring in which both verbatim repetitions and errors of tense and number were accepted as correct. Both systems yielded the same pattern of findings, and only the results of the more liberal scoring will be discussed here. Since the total number of target words differed between blocks of sentences, each subject's and sentence's scores were converted to percentages of correctly shadowed words per block.

Within each of the two noise conditions (low, high) the data were collapsed across counterbalancing sub-groups to test the difference between means for Context and No Context conditions within subjects. In the high noise group, as predicted, shadowing was better in the Context

condition (51.2% versus 37.2%; matched-$t(11) = 5.47$, $p < .001$). The effect was also reliable across sentences ($p < .01$, sign test).

Thus, the results from the high noise group suggest that providing context cues which improved the comprehensibility of target sentences also facilitated their perception. However, given that most subjects tended to shadow by word clusters or phrases rather than by individual words, one might argue that the observed difference in performance reflected differences in short-term memory rather than in perception. By this hypothesis, the improved comprehensibility of sentences in the Context condition make sentence fragments easier to "chunk" and hold in memory until the response could be completed. If so, then both noise groups should have exhibited a significant context effect but at different overall levels of performance, since only noise level differed between groups. However, in the low noise group the means for Context and No Context conditions did not differ significantly (76.7% versus 71.8%, respectively; matched-$t(11) = 1.14$, n.s.). Furthermore, among the 21 sentences whose means differed between the two contextual conditions, only 14 had a higher mean score in the Context condition ($p < .10$, sign test). Given these results with the low noise group, the significant effect of context for the high noise group is best attributed to perceptual rather than memorial factors.

Given that the effect was perceptual, it would still be of little theoretical interest if it meant only that the presentation of a context cue simply activated perceptual representations of words with which it was closely associated, or that the cue merely increased the probabilities of occurrence of senantically related words so that they could be identified on the basis of minimal perceptual information regardless of

their sentential context, If either of these hypotheses were valid, then the comprehensibility of target sentences per se would be irrelevant to shadowing performance in the two contextual conditions.

As a partial test of the associative hypothesis an independent group of 52 subjects drawn from the same pool were asked to free associate to each of the 24 context cues, each subject giving his or her first response to each item. Of the 1248 responses, only 33 (2.64%) were words which occurred in the target sentences, and two of the sentences accounted for 23 of these 33 responses. Thus, it is quite unlikely that the context cues facilitated perception by priming representations of their close associates.

The second study was designed to further test both of the above alternative hypotheses.

EXPERIMENT 2

If the perceptual facilitation provided by context cues in the first experiment was due solely to relationships between cues and corresponding target words considered individually, rather than to the improved comprehensibility of each target sentence as a whole, then context cues should facilitate perception of corresponding target words even when they occur in incomprehensible sentences. Thus, according to this hypothesis, if the cue bagpipes facilitated shadowing of the phrase the seams were split in the sentence The notes were sour because the seams were split, the same cue should also facilitate shadowing the seams were split in the sentence The buildings were tall because the seams were split. However, if the context-dependent comprehensibility of the sentence as a whole was the key factor in Experiment 1, then one would predict the following: without the context cue, both sentences

would be essentially incomprehensible, and shadowing a given phrase common to both should be uniformly poor; given the (same) context cue, one sentence would become comprehensible while the other would remain incomprehensible, and shadowing their common phrase should be easier when it is part of the comprehensible sentence. This hypothesis was tested in Experiment 2.

Method

Subjects. Forth University of Colorado undergraduates from an introductory psychology course partially fulfilled course requirements by voluntarily participating as subjects. All were native speakers of English with normal hearing and none had any language impairment.

Materials and Apparatus. Test materials consisted of eight fillers and 24 pairs of target sentences, plus corresponding context cues. All target sentences were of the form The (phrase) because the (phrase), and within each pair the portion following because was the same, as in the the seams were split example above. Pair members, differing only in their initial phrases, were constructed such that one member was comprehensible given an appropriate context while the other was incomprehensibile whether or not it was accompanied by that same cue, as illustrated above. Henceforth, these two sentence types will be referred to simply as comprehensible and incomprehensible, but bear in mind that "comprehensible" means comprehensible only in context.

Stimulus tapes were prepared from a master tape on which all 48 target sentences were recorded by a female speaker with normal intonation. Each stimulus tape contained two blocks of 12 target sentences plus two initial and two final fillers per block, with each block con-

taining a random ordering of six comprehensible and six incomprehensible sentences; no tape contained both versions of the same sentence. There were four tapes: two were made by simply re-recording sentences from the master tape; the other two were constructed by cross-splicing initial and final (post-because) portions of sentences within each pair and then re-recording the spliced versions. This permitted any acoustic differences between the final (target) phrases of matched comprehensible and incomprehensible sentences to be counterbalanced across context and sentence type conditions. The inter-sentence interval on all tapes was approximately five seconds.

The context cues were typed on white note cards as in Experiment 1.

Design and Procedure. Subjects were randomly assigned to eight groups (five subjects per group) derived by combining the four stimulus tapes with the two contextual conditions (thus Context versus No Context was a between subjects variable in this study). Shadowing practice, presentation of materials, and instructions for the two contextual conditions were exactly as in Experiment 1 except that only the higher noise level (appropriate for roughly 50% overall shadowing accuracy) was used here. Thus, each subject shadowed two blocks of sentences, each block containing half comprehensible and half incomprehensible targets. For half the subjects all sentences were preceded by context cues presented as in Experiment 1, and for the other half all sentences were presented in isolation. Block order was counterbalanced across subjects within each context condition.

All responses were tape recorded for later scoring as in Experiment 1.

Results and Discussion

Responses were scored for the number of semantically essential content words correctly shadowed in the final phrase of each target sen-

tence, the phrase which was acoustically identical for both sentence types within a pair. For each subject these data were converted to mean percentage scores for comprehensible and incomprehensible sentence types and were entered into planned comparisons. The analyses indicated that for comprehensible sentences, shadowing was facilitated by context cues (63.3% versus 48.6%, $t(19) = 2.33$, $p < .025$), but for incomprehensible sentences the cues had no significant effect (49.7% versus 41.3%, $t(19) = 1.32$, n.s.). Furthermore, in the context condition subjects shadowed final phrases of comprehensible sentences more accurately than those of incomprehensible ones (63.3% versus 49.7%, $t(19) = 2.37$, $p < .025$), while in the no context condition shadowing was equally poor for both sentence types (48.6% versus 41.3%, $t(19) = 1.35$, n.s.). Sign tests indicated that the same pattern of results was reliable across materials as well as across subjects. When presented in context, final phrases received higher mean shadowing scores in comprehensible sentences than in incomprehensible sentences in 83.3% of the cases ($p < .002$); when presented in isolation the comparable figure was 68.2% ($p < .07$). Finally, final phrases of comprenensible sentences received higher mean shadowing scores in context than in isolation in 73.9% of the cases ($p < .02$), while for incomprehensible sentences the comparable figure was 65.2% ($p < .11$).

To summarize, the results conformed to predictions based on the hypothesis that shadowing accuracy was determined mainly by the context-dependent comprehensibility of the sentence as a whole, and not by relationships between the cue and individual target words. Thus, the three experimental conditions in which a given target phrase was part of an anomalous string yielded uniformly low shadowing performance,

while the remaining condition, in which the sentence containing the target phrase was comprehensible given a context cue, yielded significantly better shadowing. Therefore, it is most reasonable to assume that context-dependent comprehensibility also accounts for the results of Experiment 1.

General Discussion

In both of the present studies shadowing was more accurate for comprehensible word strings than for incomprehensible ones when overall performance accuracy was 50%. This difference in performance reflected a difference in perceptual rather than memorial factors, as was indicated by the fact that the two sentence types yielded equally accurate shadowing when the signal-to-noise ratio was raised sufficiently to permit a higher level of overall performance (Experiment 1). Since the results of both studies also showed that a given stimulus sentence (Experiment 1) or phrase (Experiment 2) was more accurately perceived in context than in isolation, neither acoustic factors nor any other physical, linguistic, or familiarity-based differences among stimulus materials can account for the observed performance differences. The results suggest that the critical variable was comprehensibility of the strings to be shadowed, which was in turn determined by the ease with which a subject could activate and use a context of world knowledge appropriately related to the information potentially specified by the sentence. The difficulty in doing so when the sentences were presented in isolation was significantly mitigated by preceding them with appropriate cues designed to activate relevant contextual knowledge, which improved comprehensibility and consequently facilitated perception.

In an earlier section we considered three hypotheses which might

account for the perceptual effect. The first two were similar in spirit in that both focused on previously established relationships between a context cue and individual words in the corresponding target sentence, ignoring the comprehensibility of the sentence as a whole. The first of these hypotheses proposed that the cue primed perceptual representations of its close associates, some of which appened to appear in the subsequently presented sentence. The second, somewhat broader, proposed that the cue served to increase the probabilities of occurrence of semantically or experientially related words, thereby appropriately biasing perceptual decisions based upon degraded stimulus information. However, two potential sources of support for these hypotheses failed to provide any: target words rarely occurred as free associates to the context cues; and, in Experiment 2, pairing a given context cue with a given target phrase facilitated perception when the latter was part of a sentence which was comprehensible in context, but not when the sentence remained incomprehensible regardless of the presence or absence of the context cue.

The third hypothesis proposed that a word is more easily perceived when its meaning constitutes part of a comprehensible whole as opposed to an incomprehensible collection of meanings. Obviously, the most troublesome aspect of this hypothesis is that it entails the idea that meaning is somehow apprehended prior to or concurrently with perceptual identification. Given conventional views of perception and comprehension this could not occur, since a word must be perceptually identified before its meaning can be accessed in semantic memory (e.g., Paivio, 1972, Chapter 4). Thus, no aspect of meaning should be able to influence

the perceptual identification of a word, excluding cases in which semantic context makes the occurrence of the word highly predictable (which was not ture in the present studies). Nonetheless, a number of recent studies have in fact demonstrated this apparently paradoxical effect of word meaning on perception; several such studies are discussed by Coltheart (1972) and by Turvey (1974). Two clear examples are found in experiments by Rosch (1975) and by Barclay, Anderson, and Friedman (Note 1). In Rosch's research, subjects were presented in each trial with a pair of words which named items from one or two familiar categories (e.g., vehicles). The task was to decide whether the two items belonged to the same category or to different ones. The most interesting aspect of the results for the present discussion is that priming subjects with the category name reduced latencies for "same" responses to highly representative category members even when the two words were physically identical (which of course would allow subjects to respond quickly without deciding upon category membership per se), suggesting that the facilitation may have geen perceptual. Futhermore, when the task was to respond "same" only to physically identical words regardless of category membership, priming with the category name had no effect. Rosch concluded that the original perceptual facilitation with category priming could not have been due to activation of orthographic representations of category members, since that would also have facilitated responding when sugjects' decisions pertained solely to the physical characteristics of the stimulus words. Instead, the perceptual facilitation on same-category trials must have been related to semantic information activated by the category prime-- semantic information which was somehow used in perceiving the words.

In the study by Barclay, Anderson, and Freedman, high-imagery words were easier to identify against a a white-noise background than low-imagery words matched in frequency and syllable length. The implication that word imagery, an aspect of meaning, influenced auditory perception was corroborated by the finding that when subjects were simultaneously engaged in a visual distractor task designed to actively involve imagery mechanisms, performance with high-imagery words declined significantly while performance with low-imagery words remained unaffected.

Thus, there is at least indirect empirical support for the hypothesis that the perceptual advantage of messages in context in the present study was due to their increased meaningfulness. As we have discussed more fully elsewhere (cf. Barclay, Anderson, and Friedman, Note 1), this and similar effects of meaning on perception will probably prove easier to deal with theoretically in terms of the availability and use of perceptially derived information, rather than in terms of underlying pattern recognition processes (cf. Foss & Swinny, 1973). In these terms, the present data are simply not about pattern (or word) recognition: rather, they are about the conscious realization of information potentially available as the product of the pattern recognition process.

Regarding the problem of incorporating world knowledge in models of sentence processing, the present findings suggest that it would be inappropriate to relegate the use of world knowledge to a relatively late stage of processing, or indeed to any particular post-perceptual position in a series of discrete operations. It seems more likely that world knowledge influences the constructions of various consciously available representations of a sentence, including at least perceptual

and meaning representations, and that the precise nature of its influence is a given instance would vary with such factors as task demands, strength and clarity of the input signal, processing strategies, and the relative adequacy of linguistic knowledge for constructing task-appropriate representations. If so, a subtable characterization of the role of world knowledge in sentence processing will probably prove easier to formulate in terms of a coalitional (or, synonymously, heterarchial) model than in terms of more conventional information processing models which depict an invariant sequence of discrete processing stages. Both types of models specify sets of processes which generate and operate upon various internal representations of an input; however, in coalitional models alone the manner in which the processes interrelate varies systematically as a function of situational characteristics (task demands, input conditions, etc.) rather than being invariant (Minsky, 1974; Shaw & McIntyre, 1974).

Reference Note

1. Barclay, J.R., Anderson, S.L., & Friedman, A. Direct comprehension of individually presented words. In preparation.

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Footnotes

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[1]For convenience, we do not dispute the assumption that syntax and semantics can be cleanly separated, a position which is far less acceptable to linguists and psycholinguists now than at the time the research we refer to was performed.

Addendum to Barclay, Anderson, & Swanberg

The major problem with the studies just described is that in the second experiment the expected interaction between context cue and comprehensibility failed to reach significance in analysis of variance, although the expected pattern of results was substantiated statistically by other measures (specifically planned comparisons and sign tests). Note that the presented version of the study already includes an increase over the original sample size, which was designed to add power sufficient to bring out the interaction if possible.

A third study was run in an attempt to counter this problem by using a different type of materials which would make the same theoretical points while producing less inter-subject variability. Test sentences were modeled after the sentence frame The floor was dirty so/because SALLY USED THE MOP, with the final phrase again being the critical portion to be shadowed. And again, the more difficult version (with because) could be rendered more comprehensible by providing a context cue (here, one to the effect that the mop was dirty beforehand). Unfortunately, the desired reduction in variability did not emerge, and the results were unclear.

Conclusions from the Sentence Perception Research

Since the initial proposal of the above research, the results of various studies have joined those just described in validating the approach upon which the proposed research was based and in confirming the work hypotheses involved therein. Over the last several years information processing models dealing with sentence perception have moved from a relatively strict serial ordering of pertinent perceptual processes toward a much more flexible characterization whereby non-linguistic contextual information can be brought to bear on the construction of perceptual representations of

sentences. A representative example of such a model is presented by Massaro (1975)*, and additional relevant evidence in this regard is described by Freund (1975) in the same volume.

At this point in the development of the present approach, however, I must question whether the sort of elaboration of conventional information-processing models proposed by those such as Massaro is in fact worthwhile. In order to incorporate context effects like those demonstrated by the above experiments, such models have had to give up much of the simplicity and elegance that characterized the earlier, more "serialized" versions. Close examination shows that what has been gained at the cost of simplicity may indeed not be worth the price. Essentially, in order to account for effects of non-linguistic context, information-processing models have simply added another "box" or two to the flow diagram along with the arrows necessary to get the information from one point to another within the system. However, the actual mechanisms involved have not been explicated with anything approaching satisfactory precision. Thus, while the fact of non-linguistic contextual influences on sentence perception can obviously be represented in information-processing models of sufficient flexibility, it is not at all clear that the corresponding processes can be satisfactorily explained within that framework. It may be that in order to approach such an explanation, traditional information-processing models may have to be made so flexible that they lose the precision and substance which gave them their initial appeal.

* Massaro, D. W. (Ed.), Understanding language. New York: Academic Press, 1975.

RESEARCH ON SENTENCE VERIFICATION

The manuscript which follows describes two experiments on sentence verification. Since the manuscript presents the rationale fully, further introduction is not nec ssary here. Two additional and closely related studies were also performed and are described in an addendum which follows the manuscript.

A similar version of the following paper (the former by J. R. Barclay & G. J. Jahn) has been published in the Bulletin de Psycholigie (1975).

Elastic Semantic Distance[1, 2]

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Elastic Semantic Distance

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Subject Index

1. Semantic memory

   Semantic distance

2. Context effects

   Sentence verification

Abstract

The notion of fixed semantic distances among items in semantic memory is questioned in light of two sentence verification studies in which each target sentence was preceded by either a relevant or an irrelevant context sentence. Both experiments yielded evidence that verification of true statements was reliably faster in the Relevant context condition. The evidence was mixed in Experiment 1 (visual presentation) but uniform in Experiment 2 (auditory presentation). Implications for semantic memory models which relfect presumably rigid semantic distances are discussed in terms of contextualism, a theoretical orientation which emphasizes the relationship between a model of knowledge and the events or situations in which the knowledge is manifested.

This paper questions the validity of two closely related assumptions which appear to be essential to a sizeable segment of research and theory in the area of semantic memory. The first assumption is that the subjective lexicon is organized in a relatively stable way that can be captured in some content-specific characterization (hence the search for "the" structure of semantic memory). The second is that this organization reflects the semantic distance between any two words represented therein. Operational definitions of semantic distance vary, but common to all is the notion that semantic distance indicates the extent to which two items are similar in meaning (compare, for example, the pairs MAN-BOY versus MAN-HOUSE) or the salience of one in the meaning of the other (compare BIRD-WINGS versus BIRD-EYES). We submit that any given semantic distance is not rigid, but rather is contextually determined and thus elastic. Consequently, any model of "the" structure of semantic memory which assumes and relfects fixed semantic distances would itself be context dependent, applicable only to the set of situations within which independently assessed semantic distances among test items remain reasonably stable. We furthermore suggest that the experimental situations in which current models are typically tested and refined tend to fall into a class of highly constrained and unusual situations which discourage generalization to ordinary semantic processing.

The present research is offered as empirical support for the above thesis. We begin with a brief preliminary discussion of the assessment and theoretical relevance of the semantic distance construct.

Semantic Distance

The notion of semantic distance is most easily conveyed in terms of a network model of semantic memory in which each word is represented as a node from which paths radiate to other nodes. In these terms, a model may be required to specify, for some representative portion of the network, both qualitative and quantitative relationships between items. The former can be achieved by describing the type of path linking two items directly or indirectly, and the latter would correspond roughly to the "length" of the path, determined at least in part by the number of nodes involved. The way in which a theory assigns values along this dimension to pairs of items is intimately related to the proposed structure of memory, since the set of assignments indicates the relative locations of items in the network.

Consider, for example, the representation of semantic distance in the model offered by Collins & Quillian (1969). While not their most recent formulation, its simplicity makes it more useful at this point in the discussion than their later, more elaborate revision (Collins & Quillian, 1972). The earlier p oposal depicted a strictly logical noun hierarchy, with each entry accompanied by an unordered collection of defining properties economically attached only to the highest noun node to which they apply. Support for their model was found in the results of a sentence verification task

which used superset statements such as A CANARY IS A BIRD, A CANARY IS AN ANIMAL, etc., and property statements such as A CANARY CAN SING, A CANARY HAS WINGS, etc. For true sentences, response latencies were directly related to the number of nodes traversed in finding a path between the two nouns mentioned. Thus, for example, A CANARY IS A BIRD was verified faster than A CANARY IS AN ANIMAL, and a CANARY IS YELLOW was verified faster than A CANARY HAS WINGS (since WINGS, but not YELLOW, could be most economically stored as a property of BIRD).

Revisions of this model were necessitated by later research showing that the semantic instances it embodied were inaccurate, indicating corresponding inaccuracies in the proposed structure of semantic memory. Studies by Conrad (1972), Loftus and Suppes (1972), Wilkins (1971) and others showed that while the organizational scheme might indeed be roughly hierarchial, the hierarchy was neither as logical nor as cognitively economical as initial findings had implied. Instead, the relative locations of items in the network seemed to be determined by the extent to which the words or concepts were associated with each other in a person's experience. Thus, assorted word association measures, as well as subjective ratings (e.g., Rips, Shoben, & Smith, 1973) proved to be more useful than logic-based indices of semantic distance in predicting various aspects of cognitive processing (the pattern of relevant findings is summarized below).

To illustrate a different theoretical approach to semantic distance we may briefly consider set-theoretic memory models such as those of Meyer (1970), Rips, Shoben, & Smith (1973), and Shaeffer and Wallace (1970). In such models, each stored concept is represented as a set of elements such as defining features, subsets, supersets, exemplars, and the like, and the semantic distance between two concepts is an inverse function of the number of shared semantic elements. As Kintsch (1974) notes, set-theoretic models tend to lack the elaborate theoretical machinery probably necessary to explain a suitably broad range of semantic memory phenomena, and thus tend to be narrower in application than, say, the typically richer network models.

To summarize the relevant findings, the effects of semantic distance on various probes of semantic memory constitute a set of apparently quite robust phenomena. Semantic distance is directly related to response time for generating category members (e.g., Loftus & Suppes, 1972), deciding that two items share category membership (e.g., Wallace & Shaeffer, 1970), and verifying asserted property and superset relationships (e.g., Collins & Quillian, 1969, 1970; Rips et al., 1973). Furthermore, it is inversely related to response latencies for deciding correctly that two items do not share membership in a given category, and for rejecting false statements of property and superset relationships.

This pattern of findings has been regarded as indicating significant constraints upon a structural description of semantic memory. Note, however,

that the data giving rise to these constraints were gathered under conditions rarely encountered in ordinary language use. Of course, the language user spends a great deal of time dealing with truth values of statements, operating on category membership or superset relations in one way or another, and establishing numerous other sorts of semantic relationships. But seldom are such processes performed on successive messages intentionally designed not to be semantically related in any interesting way. And as numerous studies have shown, the degree to which task demands, instructions, and stimulus variables foster establishment of semantic relationships among presented items (be they words, sentences, or whatever) strongly influences the emergent picture of memory structures and processes (e.g., Barclay, 1973; Bransford & Johnson, 1973; Bransford & McCarrell, in press).

One might suggest that this caution carries less weight in studies of simple fact retrieval, since presumably the organization of lexical information (e.g., the pattern of "storage locations" of units) is at least stable enough not to change significantly from one experimental trial to the next. But on the other hand, the apparent stability may be an artifact from situational constraints which prohibit observation of theoretically important variations in an otherwise seemingly static structure. In two sentence verification studies described below, we explored some consequences of manipulating the semantic contexts in which target sentences were presented.

EXPERIMENT 1

Previous studies of cued recall (Barclay, Bransford, Franks, McCarrell, & Nitsch, 1974) have shown that the way in which the meaning of an unambiguous word (e.g., EGG) was psychologically instantiated during comprehension varied with the sentential context in which the word was presented. The results suggested that the encoding of a target word reflected the salience of various aspects of its meaning to the event described by the acquisition sentence, even though the contextually most prominent semantic characteristic of the given recall cue for a given word was significantly greater when the cue expressed the contextually emplasized aspect of the word's meaning rather than some other aspect. Thus for example, given the acquisition sentence THE WOMAN DROPPED THE EGG, "something fragile" would be a better cue than "something tasty" for recalling EGG, while the relative effectiveness of the two cues would be reversed if the acquisition sentence were instead THE WOMAN COOKED THE EGG.

Given that context differentially emphasizes various aspects of a word's meaning, then perhaps a given fact (e.g., ORANGES ARE JUICY) could be verified more rapidly when presented in a relevant context (e.g., in the context of squeezing oranges) than when presented in an irrelevant context (e.g., picking oranges). This prediction was tested by means of a slight modification of the standard sentence verificaiton task, with response latency as the dependent variable.

EXPERIMENT 1

Method

Subjects. Forty undergraduates enrolled in an introductory psychology course at the University of Colorado voluntarily participated as Ss.

Materials, Apparatus; and Procedure. The materials consisted of 56 pairs of target sentences. One member of each pair was true, and the other, which differed only in the predicate, was false: e.g., HORSES EAT GRAIN; HORSES EAT WINDOWS. The semantic relationships expressed in targer sentences varied unsystematically across items (compare, for example, PIANOS ARE HEAVY; GUITARS HAVE STRINGS; BOOKS CAN BURN; BABIES WEAR DIAPERS). Since the target sentences were held constant across the critical experimental conditions, controlled manipulation of sentence types was unnecessary at this stage of investigation (more systematic work along these lines is currently being conducted by G. Jahn).

For each true sentence a pair of context sentences (relevant and irrelevant) was constructed, each member describing an event or situation involving the subject of the corresponding target sentence. For example, for the target sentence ORANGES ARE JUICY, the context sentences were THE GIRL SQUEEZED/PICKED THE ORANGES. Other examples, with their target sentences in parentheses, include: THE TRAVELER CARRIED/LOST HIS SUITCASE (SUITCASES HAVE HANDLES); THE SWEATER WAS ACCIDENTALLY UNRAVELLED/STAINED (SWEATERS ARE MADE OF YARN); and THE CARPENTER STEPPED ON/PULLED OUT THE NAIL (NAILS ARE SHARP).

All materials were presented on slides by a computer-controlled random access projector. On each trial the S was first shown a context sentence to be comprehended and imaged (the imagery instruction was used simply to encourage thorough semantic processing). This was followed, at the S's signal, by presentation of the corresponding target sentence. A timer was started simultaneously with the onset of the target sentence and was stopped by the S's True or False button-press response; latencies were recorded automatically.

Design. The experiment was structured hierarchically, with 4 groups of Ss (10 per group) and 4 groups of target sentences (14 per group), as schematized in Figure 1. Between major S-groups I and II, all true sentences

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Insert Figure 1 about here

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were changed to their false counterparts and vice-versa. Within each of those groups of Ss, half of the true sentences were presented in Relevant contexts and half in Irrelevant contexts (context was a "dummy variable" for false sentences), the assignments being counterbalanced across sub-groups

of Ss. Thus, each target sentence was presented equally often in the two contextual conditions, and each target sentence frame (e.g., ORANGES ARE ___) was used equally often in its true and false instantiations. The presentation order of target sentences, and consequently that of type of trial (Relevant-Trye, Relevant-False, Irrelevant-True, Irrelevant-False) was randomized anew for each S.

Results

Only correct True responses were analyzed (the mean error rate per S across all sentecces was 4.7%). Separate analyses were performed on mean latencies collapsed alternately over sentences and over Ss in order to avoid estimating missing data.

Within Ss, mean response latencies were in the predicted direction: 1208 ± 41^3 msecs for the Relevant condition and 1308 ± 44 msec for the Irrelevant condition. A shorter mean latency for the Relevant condition was found in 32 (80%) of the 40 Ss ($p < .001$, sign test, no ties). The data were cast into an hierarchial analysis of variance, with groups of Ss nested within groups of true sentences (see Figure 1) and with repeated measures on Context. The outcome provided only marginal corroboration of the pattern described above: the effects both of S-groups ($F(1,2) = p < .10$) and, more importantly, of Context ($F(1.74) = 2.85$, $p < .10$) approached but did not reach significance.[4] All other effects were insubstantial. Thus, evidence supporting reliability of the Context effect across Ss was mixed and weak.

Analyses of mean response latencies per sentence (collapsed across Ss within Context conditions) presented a more uniform picture. Again mean latencies were shorter in the Relevant condition (1211 ± 25 msecs) than in the Irrelevant condition (1316 ± 30 msecs), a pattern found in 39 (70%) of the 56 sentences ($p < .003$, sign test, no ties). An analysis of variance formally identical to that described previously disclosed significant main effects of Sentence Groups ($F(1,2) = 34.23$, $p < .05$) and of Context ($F(1,106) = 8.07$, $p < .01$); no other effects approached significance. Thus, the superiority of Relevant over Irrelevant contexts was reliable across materials (the significant Sentence Groups effect is uninteresting, indicating only that one set of sentences was responded to more quickly than the other, to the same degree in both Context conditions).

EXPERIMENT 2

A second experiment was begun simultaneously with the first in anticipation of the mixed pattern of results which in fact emerged there. On the basis of pilot results for Experiment 1, it seemed reasonably likely that inter-S variability in reading time for target sentences might mask the effect of Context. Rather than deal with that problem indirectly by using statistical transformations or by somehow correcting the data for reading time, we instead ran a parallel study in which the materials were presented auditorily rather than visually, on the assumption that Ss would vary less in auditory processing time than in reading time.

Method

Subjects. Forty-eight undergraduates from an introductory psychology course at the University of Colorado voluntarily participated as Ss.

Materials, Apparatus, and Procedure. The materials were those used in Experiment 1. Context/target sentence pairs were presen ed monaurally through headphones in a single random order used for all Ss, with 3 secs between the end of the context sentence and the beginning of the target, and with 4 secs between trials. A brief rest period followed the 28th trial. On each trial, a timer was started by an inaudible tone inserted at the beginning of the last word in the target sentence and was stopped by the S's True or False button-press response. Stimulus tapes were prepared by cross-splicing master tapes, such that all characteristics of each target sentence (including the point at which the timer was started) were held constant across Context conditions.

The design of the study was identical to that of Experiment 1.

Results.

Data analyses were identical in form to those used in Experiment 1. Within Ss, mean response latencies per sentence were again ordered as predicted: 794 $\pm$ 26 msecs for the Relevant condition and 868 $\pm$ 26 msecs for the Irrelevant condition (overall mean error rate was w.72%). Shorter mean latencies in the Relevant condition were obtained by 36 (75%) of the 48 Ss ($p < .001$, sign test, no ties). The analysis of variance confirmed the effect of Context ($F(1,90) = 4.02$, $p < .05$) and no other effects approached significance.

Within sentences the pattern of results was the same. Mean response latencies were 800 $\pm$ 22 msecs in the Relevant Condition and 885 $\pm$ 27 msecs in the Irrelevant condition, and shorter mean latencies in the Relevant condition were found in 43 (77%) of the 56 sentences (p .001, sign test, no ties). The analysis of variance again disclosed a significant effect only of Context ($F(1,106) = 5.87$, p .025).

Thus, in Experiment 2 the predicted superiority of Relevant over Irrelevant contextual conditions was found to be reliable across both Ss and materials. The combination of results from both studies suggests that the effect of context on sentence verification is sufficiently stable to warrant consideration of its theoretical implications.

GENERAL DISCUSSION

How would the present results be explained by the types of semantic memory models discussed earlier? In network models such as that offered by Collins and Quillian (1972), two mechanisms are involved, intersection and activation. To illustrate: the sentence THE GIRL SQUEEZED THE ORANGES would be represented in part by the nodes for SQUEEZE and ORANGE, which would be

linked by paths to other concepts. Activation of any node is held to spread outward along all paths radiating from it, and presumably the paths radiating from SQUEEZE and ORANGE would intersect at the node for JUICE as well as at other points. This in turn leads to activation of the path linking SQUEEZE, ORANGE, and JUICE. Consequently, the path between ORANGE and JUICE receives more activation in the processing of this sentence than in the processing of THE GIRL PICKED THE ORANGES, where presumably PICK and JUICE would not intersect. Activation is assumed to reverberate long enough so that when the target sentence ORANGES ARE JUICY follows its Relevant context sentence, the path linking ORANGE and JUICY can be traced more easily than if less activation of that path had just occurred, as would be the case in the Irrelevant condition. Indeed, the present results are superficially similar to Collins and Quillian's (1970) finding that verification of property and superset statements was facilitated when the superset chain involved was part of the chain accessed on the immediately preceding trial. Thus, for example, the occurrence of A CANARY IS AN ANIMAL on one trial would facilitate verification (and not just reading) of A CANARY IS A BIRD on the next, since verifying the first sentence requires tracing the path CANARY-BIRD-ANIMAL, a portion of which (CANARY-BIRD) is traced again on the following trial.

An explanation of the present findings in terms of reverberating activation in a network preserves the rigidity of semantic distances by packing the flexibility necessary to deal with context effects into the processes which operate upon (or through) the relatively static network. But while that is a useful tactic in the trial and error process of establishing the optimal theoretical tradeoff between structure and process, it entails two unfortunate consequences in the present case. First, note that existing network models would not be able to generate the present results a priori, since the particular pattern of activation elicited by the context sentence on each trial was governed neither by logical relationships among items nor by such enduring characteristics as their conjoint frequency or similar associative measures, feature overlap, rated similarity, or other standard measures of semantic distance. The activation was instead a reflection of implicit emphasis on an aspect of a word's meaning as a function of the (sentential) context in which that word occurred. That is, the activation was determined by the relevance of a particular property of an object with respect to the event or situation described by the context sentence, which in turn is determined by the S's general "world knowledge" (see Barclay, et al., 1974, for additional discussion of this point).

Of course, it is easy to extrapolate to the present results from a model such as that of Collins and Quillian (1972), which offers a loosely specified network containing all concepts, all linked either directly or indirectly to each other by whatever relationships can be conceived among them. But therein lies the second problem: since it is difficult to confront so powerful a divice with hypothetical phenomena which lie beyond extrapolations from it, the likelihood of falsification is inherently and uncomfortably low.

Similar problems arise with set-theoretic models. Consider again the target sentence ORANGES ARE JUICY. JUICY could be regarded as a meaning element stored with ORANGE in some location (e.g., a given position on a

feature list) determined by such things as the degree to which the property is associated with the object, the salience of the property with respect to the object, etc. Contextual activation would presumably constitute a change in the relative location of the feature, say by moving it to a higher (more accessible) position on its list. However, there is presently no theoretically principled means of effecting that transformation appropriately, nor does it seem that such a mechanism could be added to such models without fundamentally changing their character and without rendering them relatively immune to test.

The essential problem, then, lies in the constraint that a model of semantic memory must reflect independently measured semantic distances which are thought to indicate the relative accessibility of stored information, as manifested for example in processing time. But what is the semantic distance between, say, ORANGE and JUICY? The position adopted here is that it depends on whether the orange is being picked or squeezed, thrown or bitten, photographed or punctured, juggled or crushed-- in short, it depends on the event or dituation in which the orange is participating at the moment of inquiry. Consequently, semantic distance can be regarded as fundamentally elastic rather than fixed, implying a corresponding variability in "the" organization of the subjective lexicon.

The fact that operationally defined semantic distance has frequently been mirrored by various processing characteristics may be largely due to similarities between assessment and test situations. In both, as a rule, the investigator takes pains to ensure that items presentee on successive trials are semantically related in only trivial ways which hopefully will exert no discernable influence on performance. Thus it is not suprising to find reliable relationships between processing characteristics and such things as conjoint frequency, category dominance, and similar "normative" measures. Given no particular context to which to relate the meanings and inter-relationships of presented words, a reasonable cognitive strategy would be to assimilate them to knowledge about contexts with the highest probability of occurrence in the environment, which in turn yields stable patterns of responses across essentially homogeneous subjects (see Bransford & McCarrell, in press).

To summarize, the issue concerns two basic positions with respect to the relationship between semantic distance (as typically assessed) and the momentary state of activation in the processing system. According to network models, the two are independent, and context-induced activation simply facilitates traversing a fixed distance between stored items. By analogy, the fact that it now takes less time to fly from New York to Paris than it did twenty years ago does not indicate that they have moved closer to each other. However, to extend the analogy, we might stipulate that in order to be theoretically useful, "travel distance" must be defined so that it directly indicates the facility or time required in getting from one place to another, just as to be theoretically useful "semantic distance" should indicate the relative accessibility of information. In that case, faster access would correspond to shorter "distance". But in any case, if semantic distance is held to be independent of "activation of pathways" or some similar notion, its usefulness as a predictor of processing characteristics is

confined to situations in which no relevant portion of the system has recently been activated, and similar constraints apply to corresponding structural models. Unfortunately, such situations are quite unrepresentative of ordinary language processing and fact retrieval. Of course, even when presented items are intended to be relatively unrelated to each other semantically, the experimental situation (materials, task demands, instructions, Ss' expectations, etc.) does not eliminate context, but instead provides a particular (and usually peculiar) context itself, one which differs from ordinary lagnuage processing situations in numerous wasy which are as important as they are obvious.

One can, on the other hand, regard semantic distance as essentially elastic, that is, inseparable from the momentary state of activation in the relevant portion of the system. This too leads to the notion of inherent variability in structural models of the types currently favored, since organizational models which reflect context-dependent semantic distances must themselves be context-dependent. This seems reasonable given that knowledge structure is an abstraction derived from observed regularities in knowledge use; that is, the structure of knowledge is the s ructure of a class of acts of "knowing." When we severely constrain those acts by attempting to minimize contextual influences, we see what appears to be a stable organization of knowledge, but when we alter the nature of the acts by admitting a broader scope of contextual influences to be observed we permit different sorts of regularities to be observed and "the" structure of knowledge seems to change.

At this point the question of rigid versus elastic semantic distances gives way to a deeper issue, since both positions lead to the conclusion that structural models which reflect a given set of distances are context-dependent. In a trivial sense this is of course true of all theories, since one can (in principle) always arrange test situations which lie outside the domain of legitimate application of a theory. But as applied to theories of semantic memory this limitation takes on more significance, since they generally fail to indicate even passing consideration of boundary conditions; they are instead regarded as applying to any situation in which an individual processes the meaning of a word. But surely those situations do not constitute a homogeneous class of "acts of knowing," and it is for just that reason that minor manipulations of contextual factors can lead to different pictures of semantic memory structure. The remedial implication is that theories of semantic memory should be explicitly based upon and reflective of the types of events or situations from which they are abstracted (one of which, incidently, whoud be the event of verifying isolated and unrelated statements). This would have the added advantage of promoting a more serious consideration both of the types of events to be investigated and of the sorts of theories that would be most useful in understanding the processing of language.

Certainly the challenge posed by contextual considerations is not new, but judging from recent trends in semantic memory work it does seem worthy of frequent reiteration and of more serious recognition. Fortunately, definite remedial suggestions are becoming both more numerous and more emphatic,

as for example in recent papers by Jenkins (1974) and Minsky (1974). Jenkins sketches some essential features of a contextualist orientation as follows, with parenthetically added illustrations drawn where possible from elsewhere in his article:

> Contextualism holds that experience consists of events (e.g., a listener hearing a sentence). Events have a quality as a whole (the total meaning of that sentence in that context). By quality is meant the resultant of the interaction of the experiencer and the world, that is, the interaction of the organism and the physical relations that provide support the for experience. The relations can be thought of and analyzed into textures (e.g., the words and the grammatical relations among them in that context). A texture in turn consists of strands (e.g., phrases) lying in a context.

A concern with events is also fundamental to Mindky's proposal, constructed from a somewhat different perspective:

> Here is the essence of the theory: When one encounters a new situation (or makes a substantial change in one's view of the present problem) one selects from memory a structure called a Frame. This is a remembered framework to be adapted to fit reality by changing details as necessary.
> A frame is a data-structure for representing a stereotyped situation, like being in a certain kind of living room or going to a child's birthday party. Attached to each frame are several kinds of information. Some of this information is about how to use the frame. Some is about what one can expect to happen next. We can think of a frame as a network of nodes and relations. The "top levels" of a frame are fixed, and represent things that are always true about the supposed situation. The lower levels have many terminals-- "Slots" that must be filled in by specific instances or data. Each terminal can specify conditions irs assignments must meet. (The assignments themselves are usually smaller "sub-frames") (p. 1)

While these two proposals differ in numerous ways, they share a particularly valuable advantage. By taking the event as the point of departure, both focus attention on initially specifying (to some reasonable degree) whatever knowledge, stimulus characteristics, task demands, etc., can be expected to influence cognitive performance in that situation.

Two immediate questions arise with respect to a contextualist approach of this sort. First, how does one systematically specify the composition of a "frame" or define constructs like event, texture, strand, etc., when these vary from one situation to another? Second, how does one select theoretically interesting and informative events, situations, or frames? As for the first question, the contextual relativity of such constructs need not present a problem as long as the definitions assigned in a given instance are useful

that is, that they are sufficiently clear with respect to the situation involved, and that the overall pattern of relationships among constructs is mirrored at the level of their instantiation. There need not be any theoretical or meta-theoretical algorithm for generating such definitions. Rather, the basis for instantiating the constructs would lie, at least initially, in the "sophisticated intuitions" of the investigator, where it is usually found anyway, especially in the early stages of applying a new approach. As for the problem of selecting "appropriate" events, this too has always been, and can remain as, primarily dependent upon sophisticated intuitions which are evaluated indirectly by the research community (Kuhn, 1972).

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Footnotes

1. Order of the two senior authors was determined by a coin toss; junior authors are listed alphabetically. Preparation of this paper was supported by grants from the National Institute of Education (NIE-G-74-0019, Barclay; , Bransford) and from the U.S. Navy, Research and Development Division.

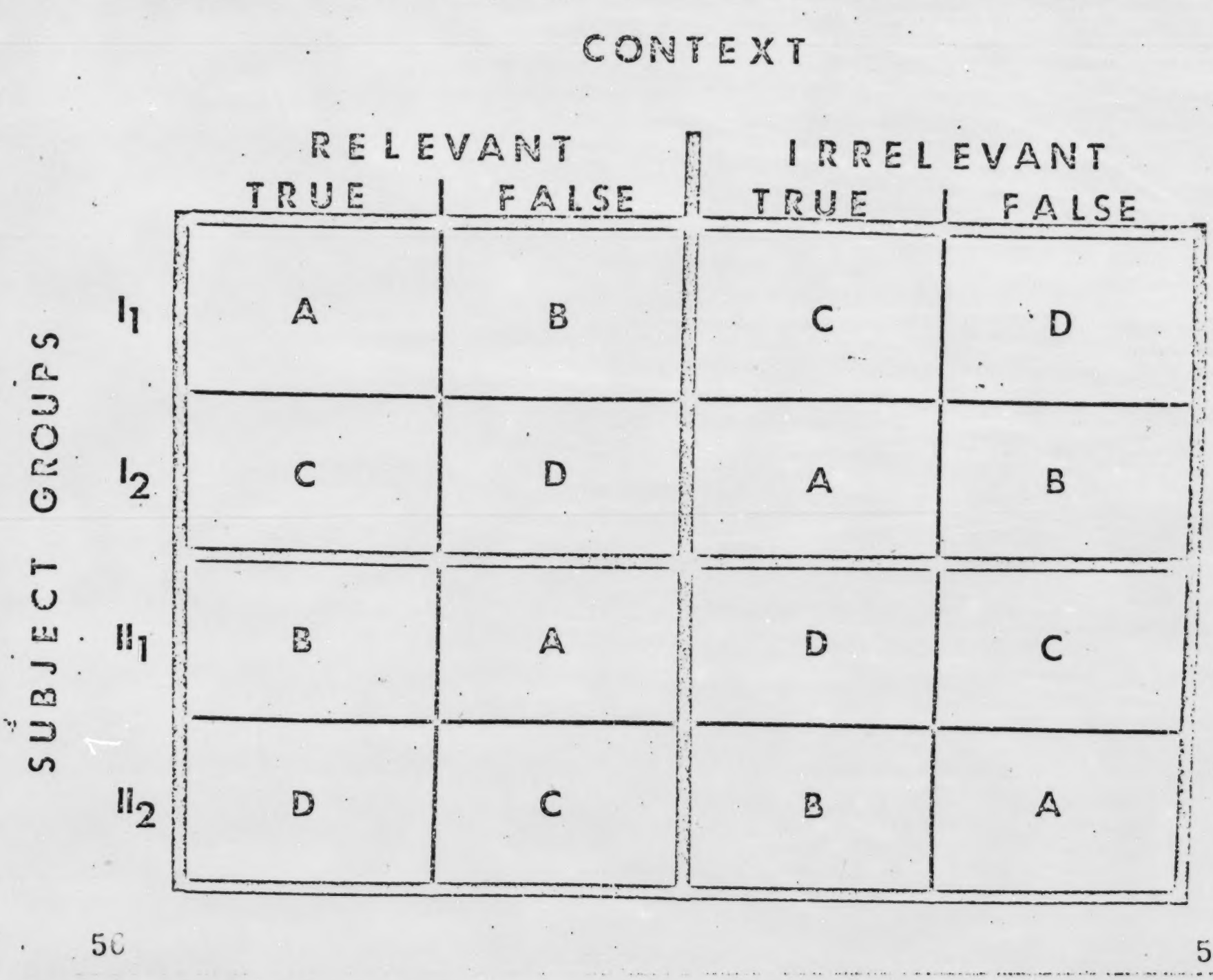
2. Requests for reprints should be sent to J. R. Barcaly, Department of Psychology, University of Colorado, Boulder, Colorado 80302.

3. The numbers accompanying the means are standard errors.

4. The main effect of Context in this and all other analyses of variance reported here was tested against a pooled error term in accordance with procedures outlined by Meyers (1972).

Figure Caption

1. Design of Experiments 1 and w. A, B, C, and D refer to separate groups of 14 sentences per group.


CONTEXT
RELEVANT
IRRELEVANT
TRUE
FALSE
TRUE
FALSE
SUBJECT GROUPS
I1
I2
II1
II2
A
B
C
D
C
D
A
B
B
A
D
C
D
C
B
A

Addendum to Bransford et al.

Two further studies were run in an attempt to rule out network-theoretical explanations of the above data based on mechanisms involving activation, intersection, and priming effects. It was hypothesized that if static network models are in fact valid, than the observed context effects could be explained in terms of pre-activation (priming) of k pathways which have fixed semantic distances rather than flexible ones. However, if the distance of a path between two word nodes is fixed, such that systematic variability in verification times reflects only whether or not the path was pre-activated, then the verification times for a given sentence presented under differing contextual conditions should all correlate with each other and with subjective ratings of semantic distance within the critical word pairs drawn from the sentences. Thus, in a third study, subjects were asked to verify the same target sentences used in the previous experiments, but this time the variable of relevant versus irrelevant context was deleted and the items were presented in isolation. In a fourth study, subjective ratings of semantic distances between critical words were gathered.

The pattern of inter-correlations failed to conform to expectations based on network models, thus providing additional support for the present view. Interestingly, positive and significant correlations were found for verification times for relevant versus irrelevant context conditions, and for verification times for isolated sentences versus ratings of semantic distance. However, no other correlations were reliable. This suggests that the results can be handled most parsimoniously by assuming that we are talking about two distinctly different sorts of situations. In one, items are being processed in context, and the data reflect a certain organization of semantic knowledge. The latter organization could also be depicted in the same sort of network model, but given the lack of uniform inter-correlations, the specific structure of the net would have to be different, and it is at least highly doubtful that either of the two nets could be reasonably transformed into the other.

While these findings are theoretically quite interesting, they apply most directly to the type of model described initially by Collins & Quillian, and that model has recently been modified significantly by Collins & Loftus (1975, Psychological Review). The newer version has been accepted at least in some important circles as a reasonable extension of Collins & Quillian's earlier work, but others (including this investigator) have found that the modifications have rendered the new version virtually, of not literally, immune to empirical falsification. In any case, the new version can, I believe, account for the above findings, and thus their theoretical impact is blunted. We are presently considering a new tack, whereby the above data would be used in more of an illustrative fashion to supplement a primarily logical arguement against network models as they are typically used

(essentially, we will argue that a particular network model applies only to a certain set of processing situations rather than being a model of completely trans-situational semantic knowledge).

RESEARCH ON "DIRECT COMPREHENSION"

In the late phases of the research program the contextualist approach implicit in the early work and explicitly discussed in the foregoing manuscripts began to assume a somewhat clearer form, although it is obviously still in primitive stages of development. At that point, we began investigating a phenomenon which offered an interesting theoretical, counterpoint to the types of contextual influences we had been researching, and which was otherwise theoretically intruiging in various ways. Specifically, the phenomenon was that of a perceptual advantage for high imagery words (versus low imagery words) in tasks involving the identificaiton of isolated words presented under perceptually impoversihed conditions (brief exposure, noisy background, etc.). More generally, the phenomenon seemed to be an instance of "direct comprehension," which refers to cases in which it appears that subjects apprehended the meaning of a presented word or object before they perceptually identified it.

Since we were at this time in the process of trying to work out a contextualistic metatheory, it was of considerable interest to see whether we could develop one which would apply as well to phenomena relatively free of contextual influences as to those heavily influenced by contextual factors. This and other relevant issues as well as our initial research are discussed in the following manuscript. An addendum concerning the future status of direct comprehension work concludes the report.

Direct Comprehension of Individually Presented Words[1]

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Abstract

When identification was the sole task, auditorily presented high imagery words were easier to identify against a white-noise background than low-imagery words of the same frequency and syllable length. However, the addition of a concurrent visual distractor task (watching a reversible figure) eliminated the perceptual advantage of high imagery words without disrupting performance on low imagery words. The findings are discussed with respect to two issues: one is the implication of visual imagery mechanisms in (auditory) word identification; the other, the primary focus of the present paper, is the notion of "direct comprehension," which refers to phenomena in which comprehension of a word does not seem to depend upon its prior identification.

while it appears intuitively obvious that a presented word (or other symbol) must be perceptually identified before it can be comprehended, a growing body of findings suggests that perceptual identification is not necessarily prerequisite to semantic interpretation. Instead, the two processes may be cotemporaneous, at least under certain conditions. For example, in a series of studies by Wickens and his colleagues (Wickens, 1972), subjects were able to report whether a briefly exposed, masked target word was semantically similar to a following comparison word even when they could not identify the target. Similarly Lewis (1970), using a standard dichotic listening paradigm, found that the latency for shadowing individually presented words varied as a function of their semantic relationships to distractor words presented simultaneously in the unattended channel, whether or not the subjects could name the distractors. Both sets of findings contradict the traditional assumption that identification must precede comprehension, since the latter implies that making any semantically based response would presuppose knowing which words had been presented. For convenience, we will use the term "direct comprehension" to refer to cases such as these in which the sequence of identification followed by comprehension is apparently violated. The major purpose of the present study was to further investigate direct comprehension, which, if firmly established empirically, would have interesting theoretical implications.

If the availability of semantic but not orthographic or phonological information in Wickens' and Lewis' studies reflects a sequence of underlying processes, then their results indicate direct comprehension. How-

ever, it is possible that identification information was available before semantic information but decayed more rapidly, so as to be lost by the time it was called for. If so, semantic aspects should be uninfluential in perceiving words or similar units when memory demands and distraction are minimized. Several recent studies have instead shown the opposite. For example, Henderson (1974) found that meaningful letter strings (e.g., YMCA) were more rapidly compared in a binary classification task than were meaningless ones of comparable orthographic and phonological regularity. Similarly, Novik (1973) found that meaningful consonant triplets took longer to reject as words than did meaningless ones. Such findings suggest that the "word superiority effect" (e.g., Reicher, 1969; Wheeler, 1970), whereby a letter embedded in a word is easier to identify than one embedded in a nonword, may also reflect direct comprehension, although explanations in terms of orthographic regularity seem to be generally preferred(e.g., Baron & Thurstone, 1973). Consider also a most intriguing phenomenon reported by Jonides and Gleitman (1972). Subjects searched letter or digit arrays for the target "O", described by the experimenter either as the digit zero or as the letter O. Response latencies showed that it was easier to find a zero among digits than among letters, indicating that the category to which the physically invariant target was pre-assigned affected its perception. Further support for direct comprehension comes from recent priming studies by Rosch(1975). In one experiment, subjects were timed as they decided whether or not a pair of simultaneously presented words (or pictures) both named members of the same category. When the stimuli

were physically identical, priming with their category name quickened same responses to "good" (prototypical) category members and slowed same responses to "poor" ones, suggesting that processing the category name activated information used in perceiving the names (and shapes) of some category members. This information was apparently semantic rather than physical, because when Ss were instead instructed to respond same only to physical identity (thus discouraging semantic processing) the category prime was ineffective.

More straightforward evidence on direct comprehension is available from studies of auditory word identification and of visual recognition thresholds. Verbal associative meaningfulness or m (Noble, 1952) was found to be inversely related to visual diration thresholds in studies by Johnson, Frincke, and Martin (1961) and by Paivio and O'Neill (1970), although the small correlation they found did not emerge in a similar study by Winnick and Kressel (1965). Similar studies involving another semantic dimension, imagery-concreteness, have also produced mixed results. For example, Spreen, Borkowski, and Benton (1967) found auditory recognition of words presented against a white-noise background to be directly related to their imagery-concreteness values, and Riegel and Riegel (1961) found a negative correlation between concreteness and visual duration thresholds. However, two later visual threshold studies failed to replicate Riegel and Riegel's results (Paivio & O'Neill, 1970; Winnick & Kressel, 1965). Moreover, the Paivio and O'Neill research implicated uncontrolled familiarity as a plausible basis for the earlier positive findings. Thus, although the weight of the findings favors

independence of imagery-concreteness and word perception, there is some evidence of correlation.

Since an effect or meaning on overt word identification presents the clearest demonstration of what we mean by direct comprehension, an identification paradigm was chosen for the present research. Of the two aspects of meaning most thoroughly studied in this regard, m and imagery-concreteness, m has received more empirical support as a perceptually influential variable and might therefore seem the best candidate for further investigation. However, persuasive evidence of an effect of word imagery on perception would generate a substantially richer set of theoretical implications, including as a subset those of direct comprehension per se. For example, consider Neisser's (1967) proposal that the mechanisms of imagery are continuous with those of perception. Several experiments have supported this contention. In studies by Atwood (1971), Brooks (1967, 1968), and Segal & Fusella (1970, 1971), subjects maintained images while simultaneously processing visual or auditory input. Performance was worse when imagery and input involved the same modality rather than different ones, even when the task was simple signal detection as in the Segal and Fusella research. While these intra-modal interference effects support the notion of continuity between perceptual and imaginal processes, they do not afford many constraints on describing the continuity more precisely. An effect of a world's imagery on its identification would provide theoretically useful input to this description since the effect would extend the continuity to more specific mechanisms-- those which identify the word and those which generate an image of its referent.

With these considerations in mind, pilot work was undertaken to assess the feasibility of research along these lines. In what was essentially a straightforward replication of Spreen et al. (1967), subjects were asked simply to identify words presented over headphones against a white noise background, with signal/noise ratios appropriate to an overall performance level of approximately 50% accurate identifications. Half of the randomly ordered stimuli were concrete, high imagery words and the other half were abstract, low imagery words. The two sets were matched in frequency and syllable length. The pilot results disclosed a modest (12%) but extremely consistent advantage for high imagery words. A second pilot study using a different (but overlapping) sample of words and a different selection of signal/noise ratios yielded the same effect. Thus, both pilot studies yielded evidence of direct comprehension in that the identification of a word apparently depended in part on an aspect of its meaning. These findings are at best only mildly interesting in themselves, since two considerations dilute the conclusions one might draw from them. First, given the inconsistency of imagery effects across previous studies of this sort, a replication of one of them without noticeable methodological improvements would leave the current picture unaltered. More importantly, one could always maintain that some unnoticed physical or experiential variable was confounded with imagery value, despite careful counterbalancing. Thus, a more persuasive domonstration would be necessary.

Assume for the moment that high imagery words are in fact easier to perceive than low imagery words because imagery mechanisms contribute differentially to word identification. Given the intramodal interference

effects mentioned earlier we hypothesized that concurrent visual processing would selectively impair auditory identification of high versus low imagery words, interfering more with the high imagery ones. The present study was designed to test this hypothesis.

Method

Subjects

Thirty undergraduates from an introductory psychology course received course credit for their voluntary participation.

Materials and Apparatus

Ninety target words were selected from the Paivio, Yuille, and Madigan (1968) norms. Half were concrete, high imagery nouns (mean ratings were 5.6 or above on both concreteness and imagery) and the other half were abstract, low imagery nouns (mean ratings were 2.4 or below on both concreteness and imagery). Item selection was further constrained to exclude homophones, ambiguous nouns, and those which are also commonly used as verbs. Three blocks of 30 targets were constructed from this set, with the following variables combined factorially within and across blocks: imagery value (high, low), frequency of usage (low, medium, and high, corresponding to Thorndike-Lorge counts of 1-9, 10-49, and 50 or more per million), and syllable length (1-4). Two filler items initiaged each block, and order of targets within blocks was random but for the constraint that no more than 2 words of a given imagery type and frequency occur consecutively.

Stimuli were tape recorded on one channel after being filtered through an automatic gain control which minimized intra- and inter-word intensity differences. The inter-word interval was 3 seconds, and the inter-block

interval was 10 seconds. During presentation the output of the tape recorder was mixed with that of a white noise generator (coupled with a decade attenuator) for binaural presentation through headphones. Signal strength was held constant at approximately 60 dB, and noise level was varied to produce signal/noise ratios of -1, -3, and -4 dB (an additional variable).

Procedure

Each individually tested subject was assigned (primarily by order of appearance) to one of two groups, control and interference, within 15 subjects per group. All were instructed to immediately repeat each presented word aloud, and to guess if uncertain; no feedback was provided. After 20 practice trials at the lowest noise level with words drawn from the middle of the imagery continuum, the three blocks of target items (plus fillers) were presented, each at a different noise level. An ascending order of noise levels was used throughout to maximize performance. Order of blocks and pairing of blocks with noise levels was counterbalanced within groups.

Control and interference conditions differed only in that interference subjects were additionally instructed to attend to a reversible figure which remained before them throughout each block's presentation, and to raise a finger each time the figure spontaneously reversed. They were cautioned not to intentionally alternate attention between visual and auditory tasks, but rather to try to perform both simultaneously. Three figures were used during testing (a Necker cube, a reversible staircase, and a face/moon figure), one for each block. A fourth, the

standard vase/faces figure, was used prior to testing to ensure that each interference subject could experience spontaneous reversals without difficulty.

RESULTS

Correct responses were entered into a 2 (task) x 2 (word imagery) x 3 (noise level) analysis of variance with subjects as the only random effect and with repeated measures on the last two factors. The analysis yielded significant effects of noise level ($F(2,56) = 22.68$, $p < .001$), word imagery ($F(1,28) = 22.92$, $p < .001$), and most important, the interaction of word imagery with task ($F(1,28) = 13.20$, $p < .01$). Means per subject are displayed in Table 1.

Table 1

Mean Proportions of Correct Identifications

	Word Imagery	
Condition	High	Lo
No Interference	.52	.41
Visual Interference	.44	.46

The main effect of noise level was due to a significant decline in overall performance at the highest level ($p < .01$, Neuman-Keuls test). The interaction, in accord with our working hypothesis, reflected a task-specific perceptual advantage for the high imagery words. In the control condition, high-imagery words were accurately identified more often than were low imagery ones ($F(1,28) = 35.46$, $p < .001$), while in the interference condition the means did not differ significantly ($F(1,28) < 1$, n.s.). As

Table 1 indicates, this was because the interference task significantly impaired identification of high imagery words ($F(1,56) = 4.14$, $p < .05$) but not of low imagery ones ($F(1,56) = 2.04$, n.s.), relative to the control condition.

A second analysis of variance among the same factors was conducted to determine whether the effects reported above were reliable over materials as well as subjects. The design was again 2 (task) x 2(word imagery) x 3 (noise level), this time with repeated measures on task and noise level and with items as the only random effect. The only significant effects were those of noise level ($F(2,176)) = 5.40$, $p < .006$) and the task by word imagery interaction ($F(1,88) = 9.38$, $p < .004$). Significant min F' ratios were also obtained for these two effects, confirming their generalizability across both subjects and materials. The ratios: for noise level (df = 2.142), 4.36, $p < .05$; for the interaction (df = 1,100), 5.71, $p < .05$.

To summarize, the high imagery words were easier to identify than the low imagery words when identification was the sole task. However, concurrent visual interference eliminated this perceptual advantage by impairing identification of the high imagery words without disrupting that of the low imagery words.

Discussion

The present findings chiefly concern two issues: direct comprehension of words, and the role of visual imagery in auditory word perception. Since the major share of this discussion is devoted to the issue of direct comprehension we reserve that topic for last.

The role of visual imagery. The present findings implicate visual imagery mechanisms in the auditory identification of words denoting imageable objects, assuming that the concurrent visual task in fact engaged those mechanisms and consequently interfered with their otherwise facilitative effect on identifying high imagery words. Given that imaging and perceiving in the same modality involve common processes at some level, as indicated by the work of Atwood (1971), Brooks (1967, 1968), Segal and Fusella (1970, 1971) and others, the assumption seems reasonable.

Two points are particularly important. First, the imagery information involved in identifying the high imagery words must have been specifically visual, and therefore presumably contained at least a partial visual description of the word's referent. Should this point seem too obvious to mention, note that one could account for the perceptual superiority of high imagery words per se without involving specifically visual information. For example, the semantic representations of high and low imagery words hypothetically could differ in the presence versus absence of a "tag" indicating only that the word is imageable, additional information which when activated somehow facilitates identification of the word. Less simplistically, one might propose that imagery information in a word's semantic representation is not essentially different from other non-visual information found there, but instead is simply redundant with it; the redundancy would then be the key to perceptual facilitation. While these "non-visual" proposals might partially explain the results in the present study's control condition, they fail when addressed to its selective interference effect. It is implausible that watching a reversible figure would selectively disrupt the activation of non-visual information.

Second, consider again the proposal that imagery mechanisms are continuous with those of perception (e.g., Neisser, 1967). Three interesting aspects of that continuity were evident in the present study. One was manifested in the selective interference produced by the visual task, which would seem difficult to explain without the assumption that the visual task engaged processes shared by imagery mechanisms. Another aspect was brought out by the fact that word identification was influenced by imagery related to the word's meaning as opposed to its physical form. Essential to Neisser's proposal of continuity was the notion that identifying a pattern and imaging that same pattern both involve many of the same constructive processes. However, current theoretical instantiations of this notion do not explicitly represent any commonality among specific processes used to identify a word as a physical pattern and those used to image its referent. Thus, certain remedial modifications may be necessitated by this aspect of the present findings. Finally, note that the present study demonstrated an effect of visual imagery on auditory identification, indicating that the effect of imagery on identification was not confined to the modality in which the imagery occurred. Indeed, given the intramodal interference effects discussed earlier (see especially the studies by Atwood, 1971, and Brooks, 1967), it is more reasonable to hypothesize just the opposite: that when both the referential imagery and the physical presentation of the word involved the same modality the facilitative effect of imagery would be counteracted to some degree. Thus, for example, the perceptual superiority of words high in visual imagery should be diminished when the words are read rather than heard, since reading would interfere

with imagery processes. In a recently completed pilot study on this issue using the same stimuli used in the present experiment, subjects found the high imagery words easier to read under "noisy" conditions (a combination of brief exposure and low contrast). However, further research (in process) is necessary to determine whether the size of the observed difference in performance was restricted by possible competition between identificatory and imaginal processes within the same modality.

Direct comprehension. We interpret the present results as indicating direct comprehension in that an aspect of meaning (imagery value) influenced subjects' ability to identify words presented against a noisy background. Since the words were presented in isolation, the occurrence of any particular item was inpredictable, and thus the perceptual superiority of high imagery words could only have arisen from differences between the two words sets in familiarity, phonological characteristics, semantic characteristics, or some combination of these. The selective effect of visual interference rules against all but semantic characteristics, since it is implausible that any phonological or familiarity-based perceptual advantage for high imagery words would be offset by concurrent visual processing which has no effect on low imagery words.

Evidence supporting direct comprehension challenges the widely accepted notion that word comprehension is a processing stage subsequent to and dependent upon perceptual identification. Representative of that position are the following remarks by Paivio (1971), which conclude his review of evidence then available on the relationship between perception and various aspects of word meaning: "No one seems to have proposed a reasonable mechanism

that would indicate how referential or associative meaning might contribute to perceptual recognition... when associative and memory factors are minimized. Until such a mechanism is made explicit, the present position remains that such meaning cannot affect perceptual recognition because the stimulus must first evoke the appropriate representation before any further associative verbal process or image can be aroused." (p. 99; emphasis added)

While we agree that a suitable explanatory model would make putative demonstrations of direct comprehension much easier to accept, the weight of converging evidence since Paivio's review makes the phenomenon difficult to ignore whether or not a satisfactory explanation is presently available. We will not attempt here to formulate a precise model of this sort, but rather to clarify the issue of direct comprehension and to gather constraints useful in dealing with it theoretically.

Of course, one might simply interpret direct comprehension phenomena as reflecting part of a fixed sequence of word recognition processes. Thus, such things as perceptual differences among words which effectively differ only in meaning and the ability to make a semantically based response without knowing a stimulus word's identity would indicate the order in which semantic and identifying information are generated or accessed during word recognition, at least under certain conditions. This proposal is unreasonable since there is no direct correspondence between the variables of stimulation and the meaning of the word (except for the trivial correspondence that could be captured in a strict behavioristic formulation, where meaning would be considered simply as the response associated with the appropriate stimulus).

This presents an interesting problem, which was brought to our attention in a somewhat different form by Turvey (1974): if the results of tasks such as identification of briefly exposed or degraded stimuli, simultaneous comparisons of physically identical items, visual search, and the like do not necessarily disclose a fixed sequence of word recognition operations when comprehension seems to be direct, then it follows that such results also fail to specify a fixed sequence of word recognition operations when identification seems to be direct. Thus much of the data taken to imply or corroborate ordinal relationships among word recognition processes should properly serve only as a basis for inferring the relative availability of various types of information used ot meet task demands.

In view of this problem consider the following two approaches to the issue of direct comprehension. The first is exemplified by Henderson's (1974) proposals concerning visual word recognition; we assume that its points can be extended to the auditory domain. For present purposes the most important aspect of this approach is that sub-word units are the products of feature analysis which are referred in parallel to interconnected graphemic, orthographic, and semantic "stores," among others. Since these memory searches are conducted in parallel, the other in which semantic and identifying information are activated need not be invariant. Furthermore, the interconnections among the stores may be such that a successful match or activation in one biases decisions in another. Such a model would permit semantic information to be activated before a word's identity has been established and would account for effects of meaning on perception, thus providing a means for explaining several instances of direct comprehension. However, notice that Henderson's model requires that semantic information be indexed by unstructured

sets of features, which would presumably be the products of feature analysis prior to activation of graphemic, orthographic, and other sorts of identifying information. This provides an extremely weak constraint on a presumably efficient search process. In addition, it is difficult to see how activated semantic information could facilitate the identification of certain subsets of words (e.g., imageable ones) given that any particular aggregate of primitive perceptual features would correspond to a very large set of meanings ranging across several semantically distinct subsets of words.

Assuming that such difficulties with particular models can be resolved, the recourse to parallel processing at least offers a solution to the problem of strictly ordering processes of identification and comprehension by proposing that both occur (or at least begin) simultaneously in word recognition. However, there is a problem. If data thought to disclose temporal relationships among components of the word recognition process instead only imply the relative availability of its various products, as suggested above, then parallel models of word recognition per se would lack substantial empirical support for the same reason that sequential models do.

The second approach is less ambitious in that it does not attempt to model the word recognition process itself in the usual fashion. Instead, it assumes that subjects' response patterns can support only a very limited set of inferences about word recognition, primarily those concerning (a) the information activated during the process, (b) the knowledge necessary to generate that information, and (c) relationships between these two and variables of stimulation. Further, this approach assumes that subject-

generated data can neither support nor refute hypotheses about a specific manner in which the information is invariably activated, because a subject's responses systematically reflect the availability and use of that information, and do not necessarily reflect the manner in which it was activated.

A theory developed within this framework might then consist ot two main components. One would explicate (a), (b), and (c) above-- activated information, underlying knowledge, and their relationships to stimulus variables. The other would specify the processes by which the information is used as a function of task demands, subject characteristics, contextual factors, and other relevant aspects of the experimental situation. Note that these components do not refer to temporally distinct, sequential sets of processes; rather, they refer to qualitatively different aspects of an event, which are in turn captured in qualitatively different theoretical components. Indeed it seems most likely that activation and use of information about a word temporally overlap.

In terms of this approach, being consciously aware of or otherwise responding to a presented word's meaning but not its identity would indicate prior or superior availability or use or semantic information under certain conditions. The facilitative effects of meaning variables on overt word identification (as for example in the present study) would imply some sort of systematic relationship between the amount or types of information activated during recognition and the subsequent availability or use of identifying information <u>per se</u>. Explicating such relationships would seem to require that we add to the two components described above (or somehow incorporate within them) a set of operational principles characterizing certain aspects of their interaction.

The second approach is obviously not a solution to the word recognition problem, nor is it offered as such. Rather, it sets aside some of the most difficult problems in word recognition in an effort to explain a variety of related and seemingly paradoxical phenomena (those of direct comprehension) in a theoretically interesting and informative fashion. This theoretical tactic is essentially the one used in the development of the motor theory of speech perception (e.g., Liverman, Cooper, Shankweiler, & Studdert-Kennedy, 1967), where considerable progress has been made by focussing more on the obvious correspondence between the perceived sound of a phoneme and its articulatory characteristics, and less on the manner in which the acoustic signal could somehow be recognized and maped into an articulatory representation.

To summarize, one may interpret "direct comprehension" literally to refer to an aspect of the word recognition process whereby the activation of identifying information, as in the first approach outlined above. Alternatively, "direct comprehension" may refer to a class of phenomena characterized by the way in which semantic information is used to cope efficiently with task demands, as in the second approach. We prefer the latter on the grounds that it is presently better suited to empirical corroboration given the previously mentioned constraints on interferences that can be drawn from our major sources of data.

Finally, note (as does Turvey, 1974) that phenomena analogous to those of direct comprehension have also been demonstrated with non-linguistic materials. Consider for example the finings that objects are more easily identified as parts of a coherent scene than as items in a jumbled version of the same scene (e.g., Biederman, 1972). This implies that

object identification was facilitated either by the meaningfulness of the whole scene which included objects as parts, or by the object's own meaningfulness as a function of its relationship to the overall display, or both. In either case, apprehension of some sort of meaning facilitated object identification, a phenomenon analogous to the facilitation of semantic characterisitcs on word identification. To the extent that such linguistic and non-linguistic phenomena are similar the present issues extend beyond the domain of word processing and into a broader segment of the problem of pattern recognition in general.

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Footnote

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Addendum to Barclay et al.

It should be clear that phenomena of "direct comprehension" are of considerable theoretical and matatheoretical interest, and that a number of exploratory routes are available. We have therefore prepared and submitted a research proposal in this domain to NIE ("Studies of Direct Comprehension". J. R. Barclay, Principal Investigator).